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High Frequency Earth Rotation Parameters Estimated from the CONT Campaigns

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Abstract

We investigate high frequency variations in Earth orientation parameters (EOP) estimated from the last four CONT campaigns. The observed variations are compared to those predicted by the IERS recommended model for high frequency EOP variations. It is found that the model does not completely describe all the observed variations. We also investigate the impact of errors in the radio source positions on the estimated EOP, and we find that the apparent retrograde ter-diurnal signal seen in the EOP estimated from CONT02 are probably caused by an error in the coordinate of one particular radio source.

1. Introduction

The CONT campaigns are 15-day long campaigns of continuous VLBI observations aimed at demonstrating the best accuracy that can be achieved using geodetic VLBI. In the last decade these campaigns have been performed approximately every third year. The data observed in the CONT campaigns can for example be used to estimate and study the Earth orientation parameters (EOP) with sub-diurnal resolution. This has been the focus of a number of different studies [1, 2, 3, 4]. In this work we study the high frequency EOP estimated from the last four CONT campaigns: CONT02 (October 2002), CONT05 (September 2005), CONT08 (August 2008), and CONT11 (September 2011). We also investigate the possible systematic errors that can occur due to errors in the coordinates of the radio sources.

2. Data Analysis

The VLBI data from the CONT campaigns were analyzed with the Vienna VLBI Software (VieVS, [5]). In the analysis polar motion and UT1 were estimated with 1-hour resolution, while precession/nutation was fixed to the IAU2006/2000A model plus the IERS 08 C04 corrections [6]. Additionally, station coordinates, station clocks (1-hour resolution), zenith wet delays (30 minutes), and tropospheric gradients (6-hour) were estimated. The coordinates of the radio sources were fixed to their ICRF2 values [7] (except for the special investigations in Section 3.1). For each CONT campaign the normal equations of the 15 individual one-day sessions were stacked and then inverted in order to obtain continuous time series of the EOP as well as one set of station coordinates.

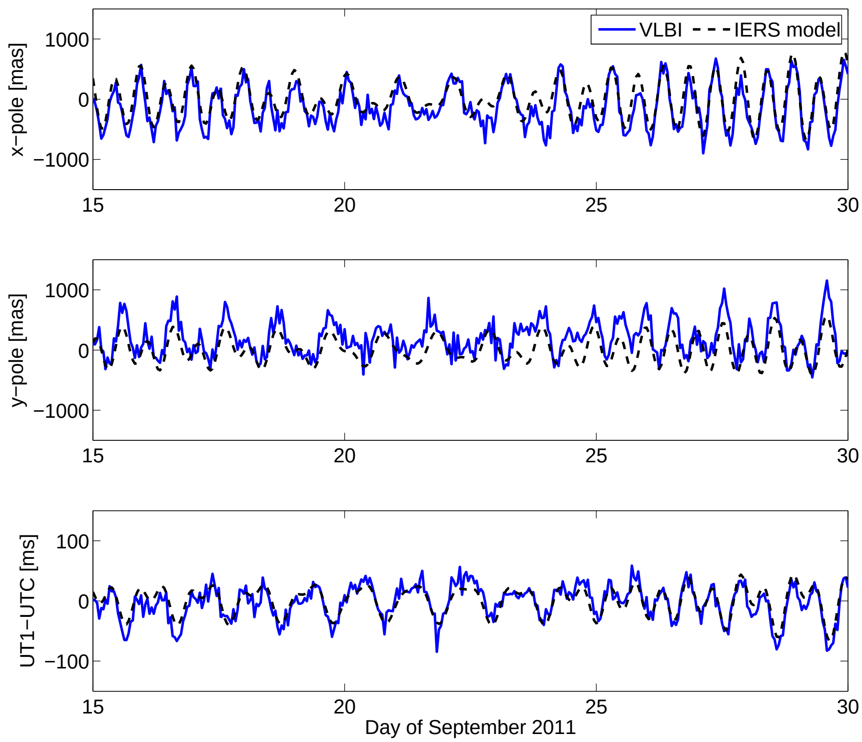

Figure 1. Time series of polar motion and DUT1 estimated from CONT11. The IERS 08 C04 values have been subtracted from the series. For comparison, the IERS model for high frequency EOP variations [8] is plotted.

3. Results

Figure 1 shows polar motion and DUT1 estimated from CONT11. The IERS 08 C04 series has been subtracted from the time series in order to remove the low frequency EOP variations, thus leaving only the high frequencies. As a comparison, the IERS model for high frequency EOP variations [8] is also plotted. Overall there is a good agreement between the observations and the model, but occasionally differences can be noted that are bigger than 50% of the effect itself.

In order to investigate these differences in more detail we subtracted also the IERS high frequency model from the observed EOP time series. Then we calculated the Fourier spectra of the remaining residuals. This was done for all four CONT campaigns. The spectra are plotted in Figure 2. A number of significant peaks can be seen in the spectra, especially at the periods of +24 hours and ±12 hours. For CONT02 there is also a significant peak at -8 hours.

An interesting question is: what are the reasons for these spectral peaks? One explanation could be that the IERS high frequency model is not correct. This model consists of two parts: the major part is a model describing the variations due to ocean tides, and the other part describes the effects due to libration. The ocean tidal part is an extended version of the model which was presented by Ray et al. (1994) [9]. Since new and improved ocean tidal models have been developed in recent years, the IERS model should probably be updated using one of these. Furthermore, it is possible that there are excitations of EOP at sub-diurnal timescales caused by other sources than

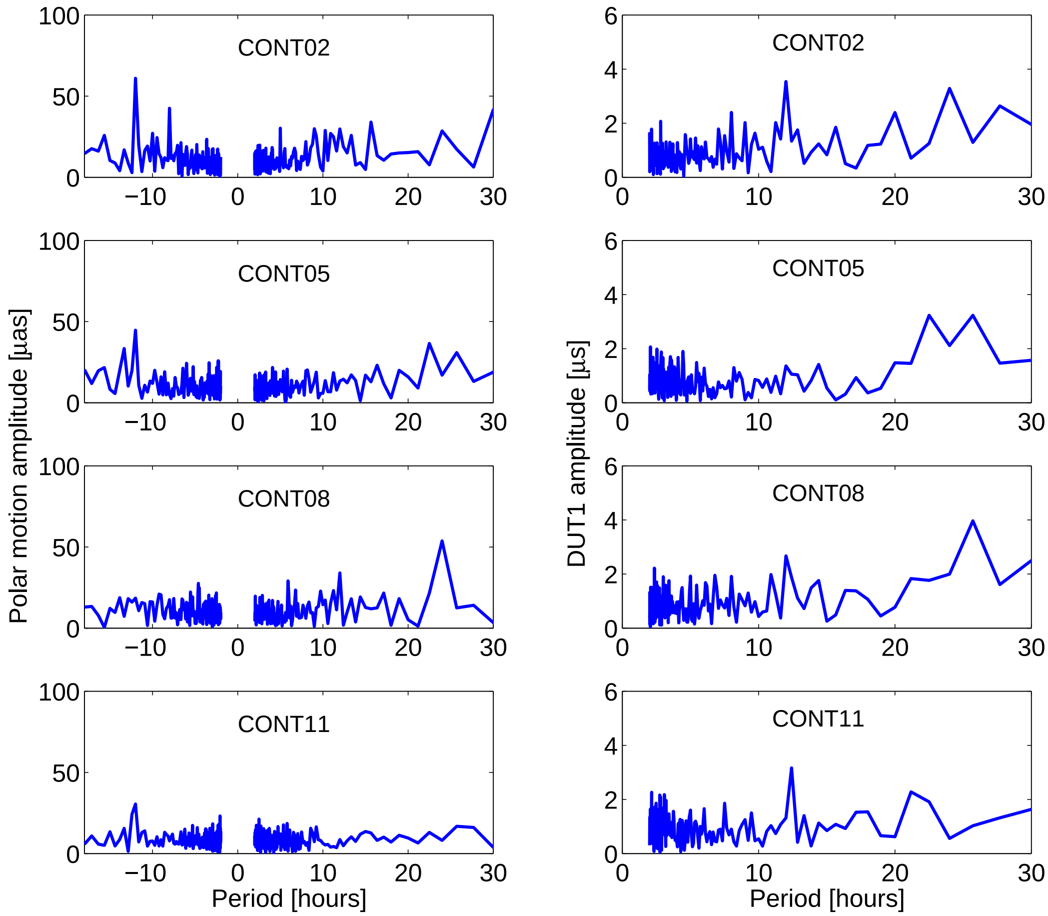

Figure 2. Fourier spectra of the polar motion ($p = x_{\text{pole}} - i\, y_{\text{pole}}$) and DUT1 estimated from the CONT campaigns, after removing the IERS 08 C04 values as well as the IERS high frequency EOP model. Positive periods in polar motion refer to prograde variations, negative periods to retrograde ones.

ocean tides and libration, for example atmospheric tides. However, by investigating atmospheric angular momentum functions calculated from numerical weather models we have found that the atmospheric excitations are too small to explain the peaks seen in the EOP spectra [4, 10]. The -8 hour peak seen in CONT02 is especially difficult to explain. There exist models that predict ter-diurnal variations in polar motion (see [1] for a review), but the predicted magnitude is much smaller than what is observed.

3.1. Estimation of Source Coordinates

The possibility that the peaks seen in the Fourier spectra are artefacts caused by errors in the VLBI data analysis cannot be excluded. An example could be errors in the coordinates of the radio sources. Although the observing schedules of the sessions of a CONT campaign are not exactly equal, they are similar, and the same sources tend to be observed using the same set of stations at the same sidereal time of day every day of the campaign. Thus, if there are errors in the

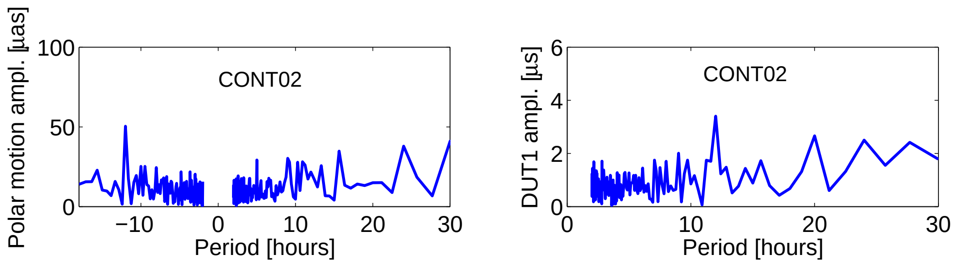

Figure 3. Fourier spectra of the EOP from CONT02 when the positions of the radio sources are estimated in the VLBI data analysis.

coordinates of the radio sources used, this could potentially cause systematic errors in the VLBI results (e.g., the EOP) with periodicity of 24 hours and/or higher harmonics (12 hours, 8 hours, ...).

To investigate this assumption we made solutions in which the coordinates of the radio sources were also estimated in the VLBI analysis. One set of source coordinates were estimated per CONT campaign. In order to stabilize the solutions, we constrained the coordinates to their ICRF2 values using their formal errors as given in the ICRF2 catalog. As an example, the spectra of the residual polar motion and DUT1 obtained from CONT02 are shown in Figure 3. We can see that there is no significant peak at the −8 hours period in the polar motion spectrum anymore and the −12 hours peak is slightly reduced. For the other three CONT campaigns there is no significant effect on the spectra when estimating the radio source positions.

It thus seems as if the −8 hours peak seen in the polar motion from CONT02 is caused by errors of the radio source coordinates. To figure out which particular sources are responsible, we took a closer look at the estimated source coordinates. Five of the estimated coordinates differ by more than 200 μas from their ICRF2 values. We made tests in which only the coordinates of one of these sources were estimated in the VLBI data analysis. The results indicate that the −8 hours peak is mainly caused by one source: 2234+282. This source is a non-defining source in ICRF2 and has a structure index of 3 in X-band (according to `http://vlbi.obs.u-bordeaux1.fr/`). Feissel-Vernier (2003) [11] investigated the stability of radio source positions. The position of the source 2234+282 was found to be highly unstable; thus it is not surprising that this source has unreliable coordinates.

4. Conclusions

There are several unexplained peaks seen in the spectra of the EOP estimated from the CONT campaigns. The −8 hours peak seen in CONT02 seems to be caused by errors in the coordinate of one radio source. Care should be taken when analyzing VLBI sessions in which unstable radio sources are observed, especially in the case of the CONT campaigns where the observing schedules of the individual one-day sessions are very similar. The other peaks seen in the spectra, however, are not caused by errors in the radio source positions. Possibly, these indicate that the IERS model for high frequency EOP variations needs to be updated using a new ocean tidal model and perhaps also including excitations by atmospheric thermal tides and other sources. Similar conclusions were also drawn in [12] when analyzing several years of VLBI data.

Acknowledgements

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